

BMAN73271 Decision Behaviour, Analysis and Support

Choosing the Ideal MSc Computer Science Program:

A Multi-Attribute Decision Problem

Tutor: Dr Nadia Papamichail

Yazhuo Cao

List Of Tables

- [Table 1. Analysis of stakeholders](#)
- [Table 2. Weights of each attribute and the sub-attribute inside their section.](#)
- [Table 3. Ranking from QS and The Time.](#)
- [Table 4. Scores based on the ranking from QS and The Time.](#)
- [Table 5. Cost, including tuition fee, accommodation fee and living cost.](#)
- [Table 6. Score based on tuition fee, accommodation fee and living cost.](#)
- [Table 7. Locations and city ranking of the locations.](#)
- [Table 8. Scores for the city ranking.](#)
- [Table 9. Course duration.](#)
- [Table 10. Scores for Course Duration.](#)
- [Table 11. Scores of the alternatives](#)
- [Table 12. Table of initial alternatives and their attribute values](#)

List Of Images

- [Figure 1. An attribute tree for MSc Computer Science choice.](#)
- [Figure 2. Stakeholder Analysis plot](#)
- [Figure 3. : Table of the five alternatives and their acronym in the report and V.I.S.A.](#)
- [Figure 4. Total and individual scores for each attribute of the alternatives](#)
- [Figure 5. A Pareto plot showing the ratios between Costs and Ranking, the colour corresponds to Figure 3](#)
- [Figure 6. Sensitivity analysis: effect of varying the weight on Ranking](#)
- [Figure 7. Sensitivity analysis: effect of varying the weight on Costs](#)
- [Figure 8. Sensitivity analysis: effect of varying the weight on Location](#)
- [Figure 9. Sensitivity analysis: effect of varying the weight on Course Duration.](#)
- [Figure 10. Radar diagram of the top three alternatives and their attribute value: Ranking, Costs and Location. Course Duration is excluded as they share the same duration.](#)

Table of Contexts

1. [Introduction](#)
2. [Formulation](#)
 - 2.1. [Stakeholder analysis](#)
3. [Evaluation](#)
4. [Appraisal](#)
 - 4.1. [Result presentation](#)
 - 4.2. [Reflection](#)
5. [Reference](#)
6. [Appendix A: V.I.S.A. decision model](#)
7. [Appendix B: Data File](#)
8. [Appendix C: Initial Alternatives and exclusion criteria](#)

Introduction

Decision analysis guide users to make a knowledgeable decision where relative criteria are systematically considered.

In this report, the author will model and analyse a multi-attribute decision problem of choosing the ideal MSc Computer Science degree using V.I.S.A., a decision support software. An initial list of 12 alternatives will be selected and screened, the suitable ones will be further analysed using 4 main attribute categories.

<https://github.com/GloC99/Reports-and-Presentations/blob/main/Machine%20Learning/Stackelberg%20Leader%20Strategy.pdf>

Formulation

The decision model is addressing the opportunity of taking a second master degree in computer science with a focus on data modelling. The MEng Computer Science the author is currently undertaking is focused on the industrial application while the author is looking for more research opportunities.

Therefore, through this report, the best MSc Computer Science programmes for the author will be identified. The situation will be viewed and the decision made from the point of view of the author, who is an international student looking for a second master degree taught in English outside of the United States, China, Japan and Korea. The reasons these countries are removed from the report's search are as follows: The United States because of the current political situation and as well as the high rejection rate of visa applications from Chinese students which make it a risky country to apply to and the latter three are because they require an entrance exam on top of the standard application requirement which complicates the application process.

The issue with this opportunity is that every university is different and there is no clear direct way to quantify and compare between the universities. To quantify and compare between universities, it will be necessary to use public ranking data as well as cost metrics and location ranking to standardize their different appeals. The several quantifiable key attributes are drawn up below in an attribute tree:

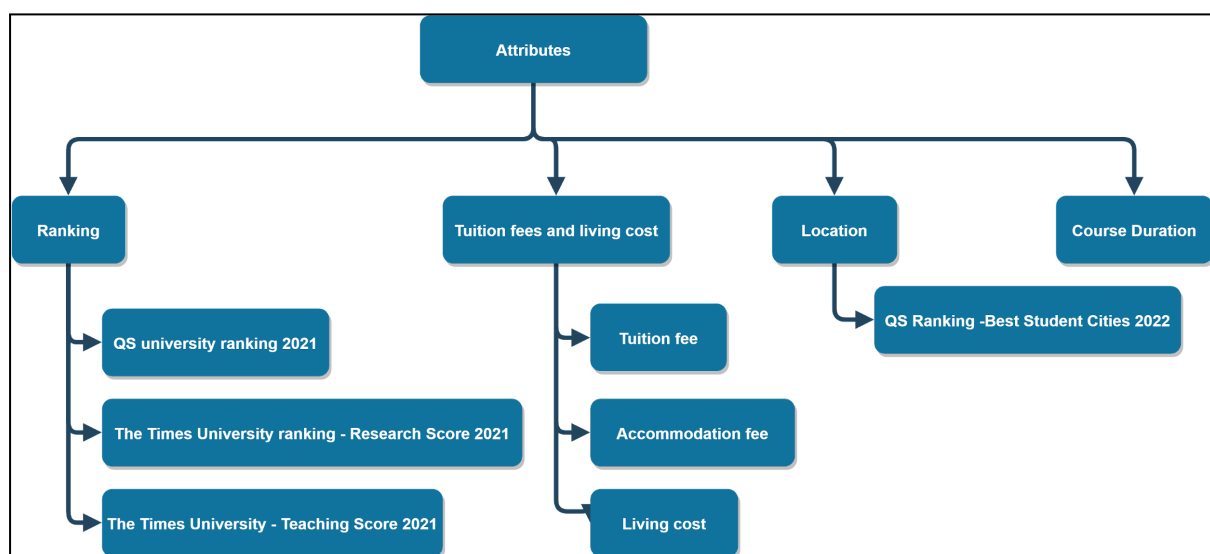


Figure 1. An attribute tree for MSc Computer Science choice.

There are, however, several constraints regarding these attributes. The QS university ranking only takes into account the university's computer science department in isolation.

To resolve concerns about the quality of our information, as studies have found a close relationship between the quality of information used by the decision-maker and their decision making performance (O'Reilly, 1982), two different university rating agencies' rankings were intentionally included, to help balance out any bias each individual agency may be guilty of.

Additionally, each university offers scholarships of different amounts. However, as scholarship applications are intensely competitive this report considers them non-consequential and as such they are not included in the calculation of the total cost. Possible income from part-time work during the academic year is also not included in the calculation because most universities on this list included estimated study time per week and warnings about balancing a demanding master degree with a part-time job. Both accommodation and living costs are estimates of the expected true value as accommodation comes as a range of options and living cost is dependent on the individual, not just the location. This means that total cost is also an estimation as it includes both the certain cost of tuition fees and the uncertain, individually determined accommodation and living costs.

Stakeholder analysis

The possible stakeholders and their analysis for this decision are shown in the table below:

Stakeholder	Power	Stake
Parents	High The cost of the degree would be paid by the parents which may lead to them weighing heavily on the final decision	High Parents would be paying for the cost of the degree which would not be returned until the author starts working and earning money. The decision has a high impact on their financial status.
Friends and family members (other than parents)	Medium They are not financially involved with the decision, however, they can influence the decision-making process.	Medium The location of the university would influence their possible travel destination and for the younger family member, their possible future university.
General Public	Low The general public has little direct influence on the author on their decision. However, their opinion on certain universities may lend towards the author favouring one university over another. (e.g. Russell Group Universities)	Low This decision would not affect the general public.
University Ranking Agencies	High The attributes are based on the results from the ranking agencies.	Low The decision would not affect the ranking agencies.
Scholarship agencies	High	Low

Stakeholder	Power	Stake
	The possible scholarship would reduce the cost of studying and therefore greatly influence the author's decision	The agencies would not be affected by the author's decision on whether to apply, accept or withdraw the scholarship.
Media	Medium The media affects the decision on its report of the news of the universities and their location.	Low The media would not be affected by the decision made.
Government	High As an international student, a study visa is necessary for studying for a degree abroad. The government has a high power as its immigration policy directly affects whether the study can proceed even if the student is sponsored by their new university.	Medium Taking in an international student is a type of education export that would affect the government's income on taxes and foreign currency. However education export is unlikely the only export any country would have therefore the stake for the government is medium.

Table 1. Analysis of stakeholders

The stakeholders are shown on a plot in Figure 2 for better representation.

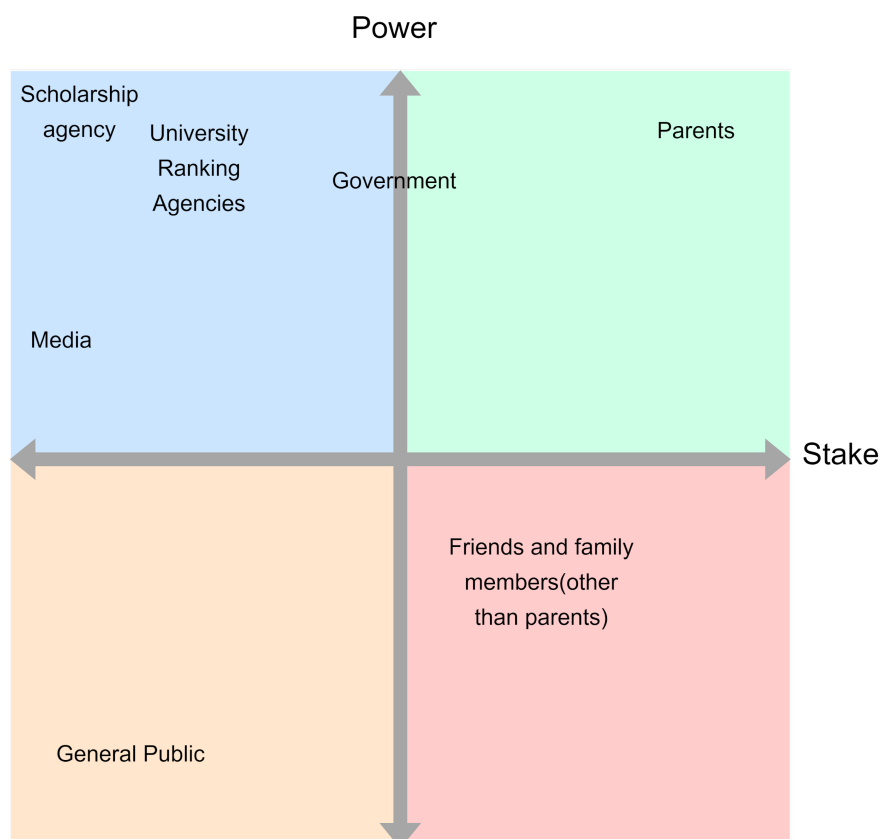


Figure 2. Stakeholder Analysis plot

A list of alternative universities was established using the QS University Ranking for Computer Science. This excluded universities that are located in the US and East Asia, with the same justification mentioned earlier in the formulation of this report.

The list of initial alternatives identified and the attributes of each of these alternatives have been investigated with the results shown in Appendix C.

To identify the alternatives worth further evaluation, requirements were drawn out to screen out unsuitable alternatives:

1. The total cost should be below £35000.
2. The length of the course should be, or below, 12 months.
3. The course must be taught in English.
4. Part of the degree syllabus must include Data engineering, Database Management and Data Modelling.

Due to the uncertainties in the cost estimation as mentioned above, universities that are estimated to have a cost of £5000 above the screen requirement are considered, however, they would also be disadvantaged in the selection due to their high cost.

The length of the cost should be below 12 months so a full-time job can be considered as soon as possible to generate income to repay the cost of the university to the parents. In some countries where a master degree is at least two years might shine an unfavourable light on a one-year master degree, however, as the ideal working location for the author is in Europe, this should not be an issue.

The location of the university allows it to connect with local employers therefore a metropolitan university maximises the chances of meeting future employers before graduation.

The table in Appendix C includes information about each attribute for each alternative. The screening result is shown in the table colour coded.

Only four universities out of the initial twelve pass the screening criteria. The National University of Singapore does not but it narrowly missed the threshold for cost and course length but is nonetheless only £615.61 over the cost limit and six months over the course length limit, it is therefore worthy of further evaluation. Others however either do not have the research direction the author wished or is over the cost limit substantially.

There are five alternatives worthy of further evaluation:

Alternative Name	Accronym used in report	Shorten name in V.I.S.A.	Colour in V.I.S.A.
Technical University of Munich	TUM	Technical	Blue
Swiss Federal Institute of Technology Lausanne	EPFL	EPFL	Magenta
Université PSL	PSL	Université PSL	Red
University of Amsterdam	UoA	University of	Green
National University of Singapore	NUS	National	Purple

Figure 3. : Table of the five alternatives and their acronym in the report and V.I.S.A.

Evaluation

A decision model is built using V.I.S.A as shown in Appendix A, the data file representing the score of the alternatives for individual criteria are shown in Appendix B.

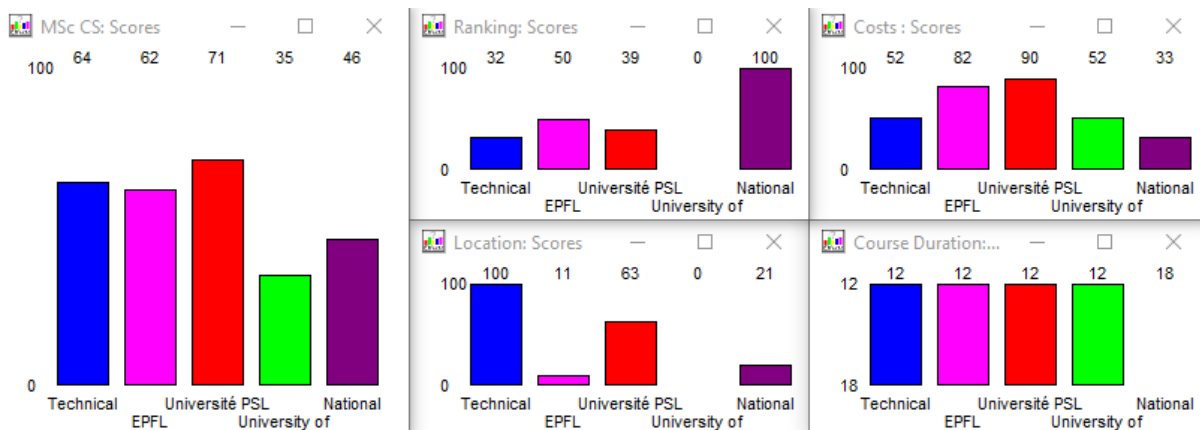


Figure 4. Total and individual scores for each attribute of the alternatives

The five alternatives above are ranked as follows with their scores shown in Appendix B and Figure 3:

1. PSL
2. TUM
3. EPFL
4. NUS
5. UoA

PSL is the top choice, however, the overall score is sensitive to the weight assigned to each attribute and therefore exposed to the possible effects of bias in problem phrasing and criteria hierarchy need to be investigated.

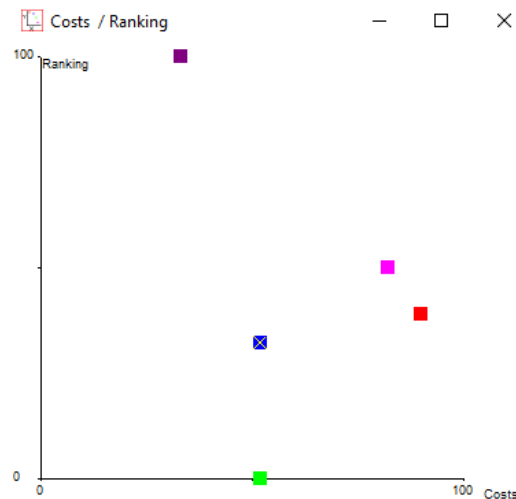


Figure 5. A Pareto plot showing the ratios between Costs and Ranking, the colour corresponds to Figure 3

As illustrated in Figure 5, in terms of the ratio between cost and ranking, EPFL and PSL are the most inclined to the top-right corner and therefore the top option in terms of cost and ranking.

As presented in Figure 6, the PSL is the best option only when the weight of ranking is below 0.51. If ranking is more important in this decision making, the NUS would be the best option with no close contestant as it has the highest ranking overall but the lowest in other attributes.

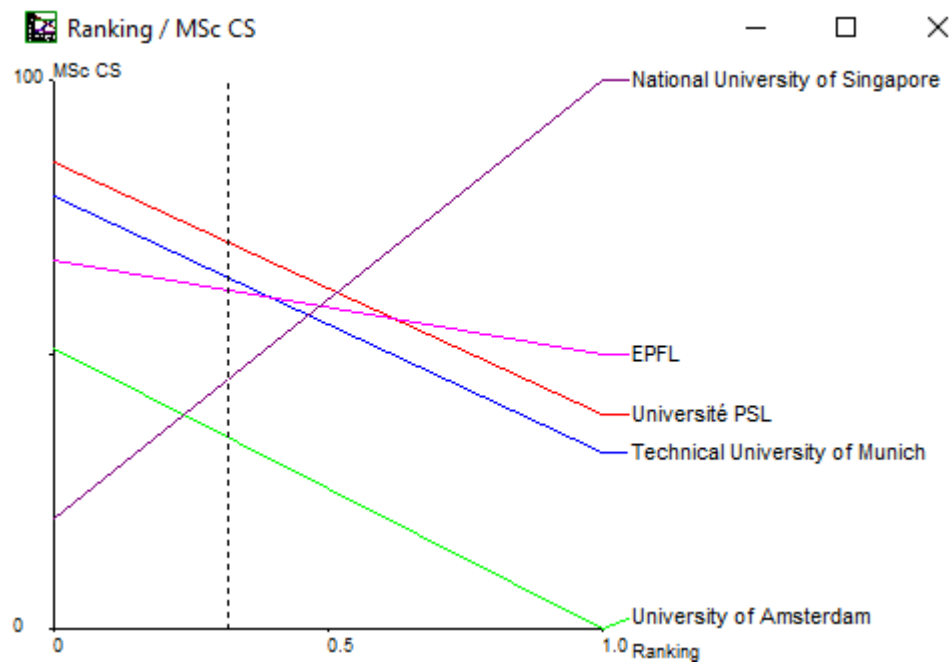


Figure 6. Sensitivity analysis: effect of varying the weight on Ranking

In terms of the cost of each alternative, it is clear from Figure 6 that PSL has an obvious advantage. Only when the weight of cost is reduced to below 0.156 the TUM would be a better choice than the Université of PSL which is the preferred alternative if the weight is any higher than 0.156.

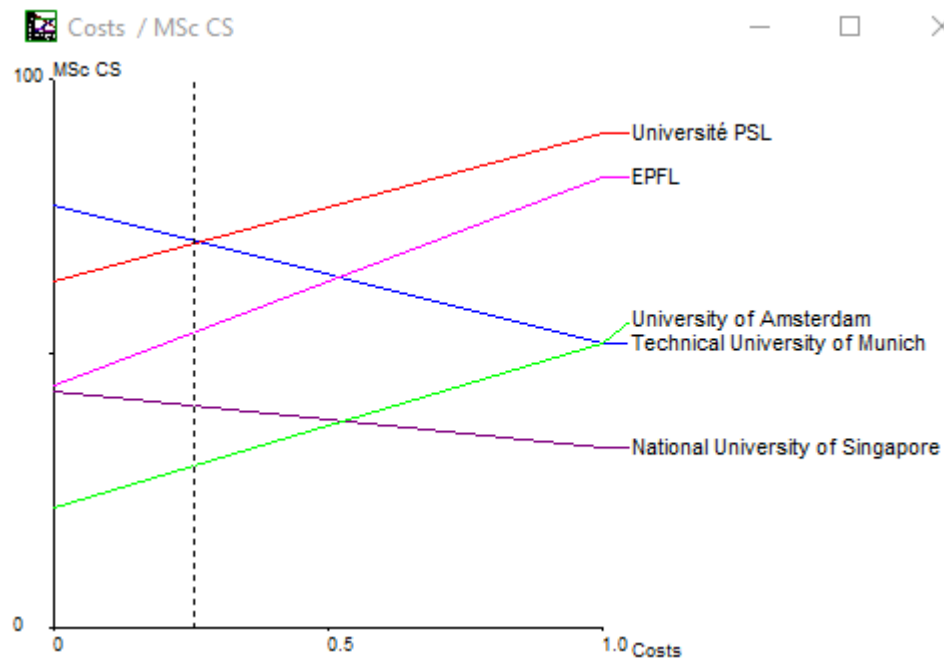


Figure 7. Sensitivity analysis: effect of varying the weight on Costs

With regards to the location of the university presented in Figure 8, PSL is only the preferred choice if the weight on it is no more than 0.333. If the location affects over a third of the decision process the TUM would be preferred instead. On the other hand, If the weight is smaller than 0.021, EPFL would be favoured instead.

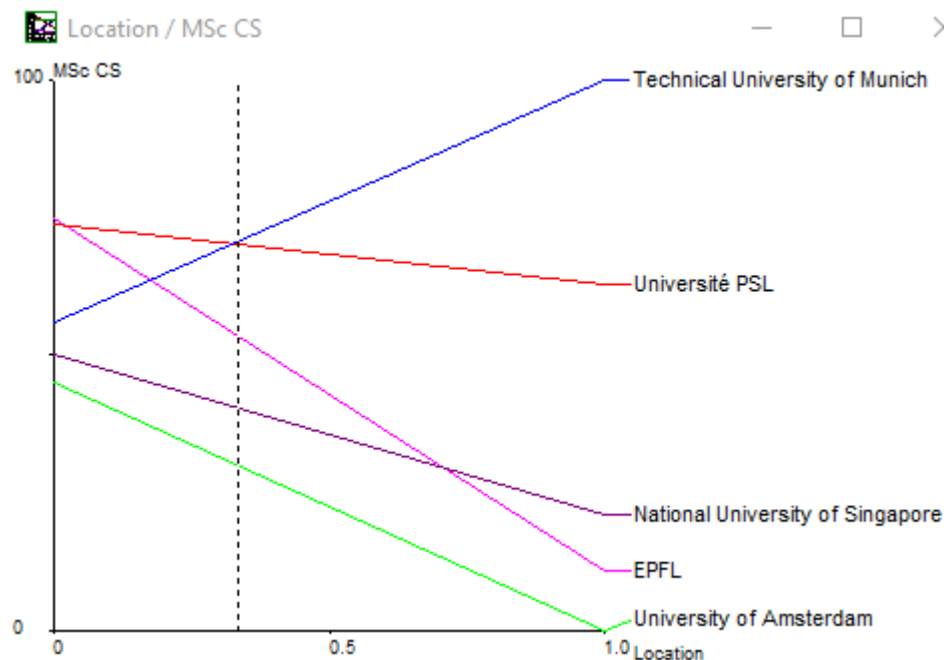


Figure 8. Sensitivity analysis: effect of varying the weight on Location

As all the alternatives, other than the NUS, has the same course duration, therefore as PSL is the preferred choice in other criteria, it stands to reason for it to further be the preferred choice as shown in Figure 9, until the course duration carries no weight in the decision.

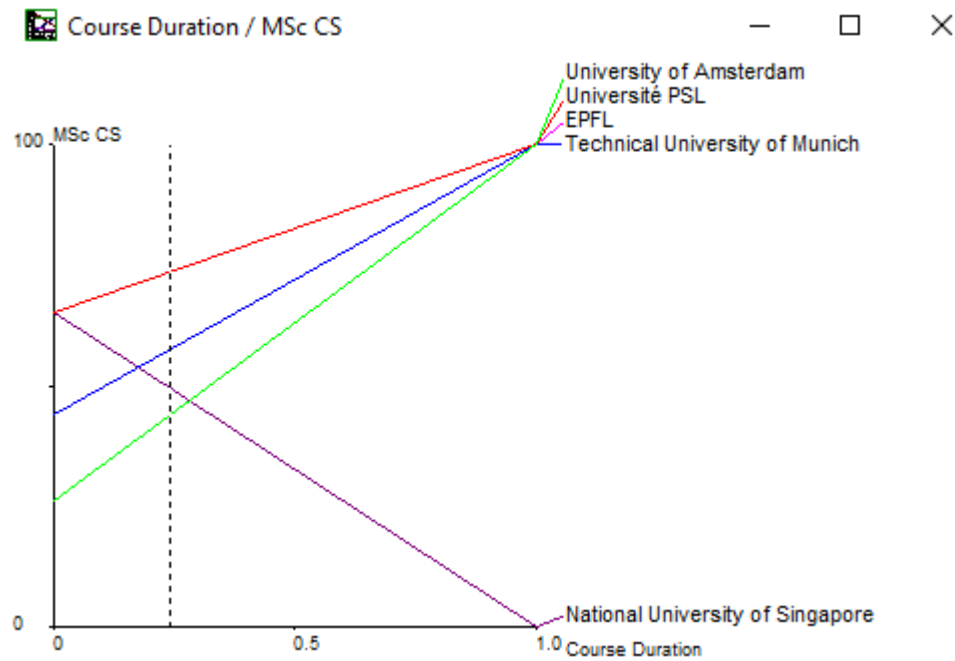


Figure 9. Sensitivity analysis: effect of varying the weight on Course Duration.

Appraisal

Result presentation

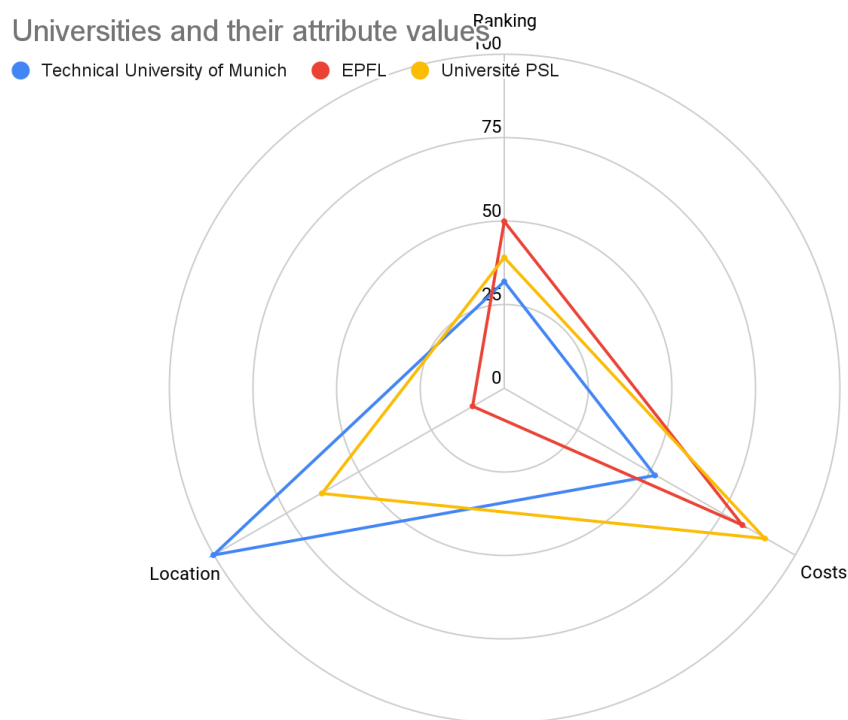


Figure 10. Radar diagram of the top three alternatives and their attribute value: Ranking, Costs and Location. Course Duration is excluded as they share the same duration.

As Figure 4 presented, the alternative with the highest score is PSL that ranked the highest in all attributes. There are two close contenders: The TUM and EPFL, their trade-offs are shown in Figure 10. Both are comparable in many attributes to PSL. EPFL has a higher score in ranking but a ten placements difference for its city ranking on QS. It would be the top choice if the cost is cheaper or the weather on location is less.

The TUM has a lower ranking for teaching in The Times but a higher ranking in its location which is why there is only a six points difference in its score out of a hundred. TUM has 38.7 students per staff whereas PSL has 15.1 students per staff which diminishes their teaching score due to their staff being spread thinner. The TUM would need to employ more academic staff to improve their performance, increase the teaching score and make them the top choice.

Due to the sensitivity analysis result shown above, the results are robust for the current situation with the given estimation. The author and high stake, high power stakeholders are comfortable with the guidance provided by this report and is happy with the top choice.

Reflection

If the decision analysis process is to be repeated, the problem formulation would be redone in close communication with high-stake, high-power stakeholders for attributes representing the problem.

What I learnt in the process of decision analysis is to use systematic thinking to divide-and-conquer the complex problems to reach the best result. Experience in researching and applying V.I.S.A was acquired and conducting this report helped me to apply the knowledge I learnt in this course into real-world problem-solving.

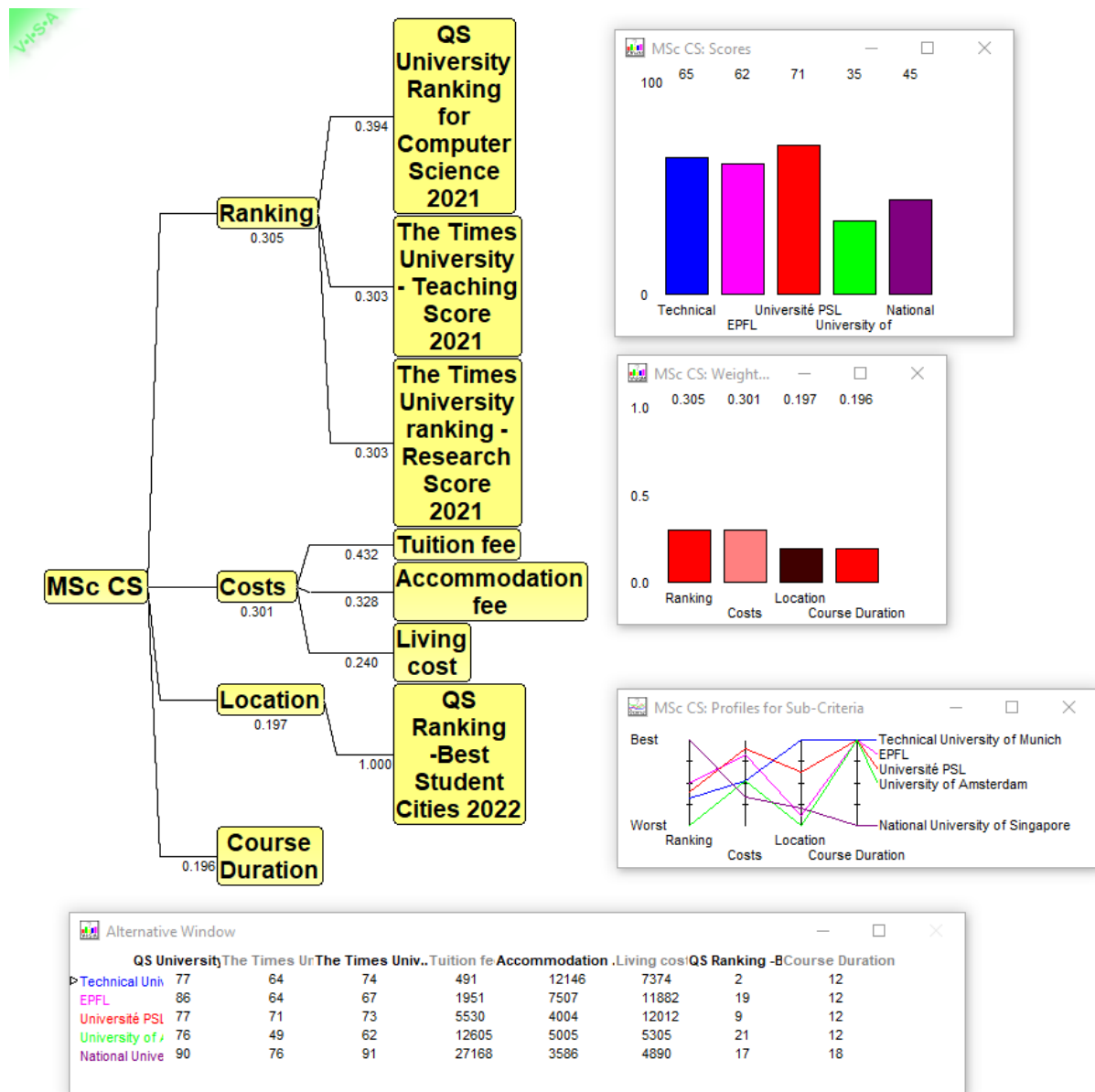
The main challenge in the course work was to assign weights to the attributes, converting from the author's idea to quantifiable numbers, nevertheless, sensitivity analysis shows the diminutive shift in weight would not change the top choice.

The V.I.S.A. has no way of assigning weight other than dragging the bar chart, making it difficult to return to a previous weight after it has been changed but overall the experience was pleasant.

Reference

O'Reilly, C.A. (1982) 'Variations in Decision Makers' Use of Information Sources: The Impact of Quality and Accessibility of Information', *Academy of Management Journal*, 25(4), pp. 756–771. doi:10.2307/256097.

Appendix A: V.I.S.A. decision model



Appendix B: Data File

Weights

Attribute	Sub-attribute	Sub-Weight	Total weight
Ranking	QS University Ranking for Computer Science 2021	0.394	0.318
	The Times University - Teaching Score 2021	0.303	
	The Times University ranking - Research Score 2021	0.303	
Cost	Tuition fee	0.432	0.297
	Accommodation fee	0.328	
	Living cost	0.240	
Location	QS Ranking -Best Student Cities 2022	1.000	0.192
Course Duration	N/A	1.000	0.193

Table 2. Weights of each attribute and the sub-attribute inside their section.

Scores

Attribute: Ranking

Source(s): Objective attribute from university ranking agencies.

<https://www.topuniversities.com/university-rankings/university-subject-rankings/2021/computer-science-information-systems>

https://www.timeshighereducation.com/world-university-rankings/2021/world-ranking#!/page/0/length/25/sort_by/scores_teaching/sort_order/asc/cols/stats

https://www.timeshighereducation.com/world-university-rankings/2021/world-ranking#!/page/0/length/25/sort_by/scores_research/sort_order/asc/cols/stats

	Original Ranking value		
	QS University Ranking for Computer Science 2021	The Times University - Teaching Score 2021	The Times University ranking - Research Score 2021
Technical University of Munich	77	64	74
EPFL - Swiss Federal Institute of Technology Lausanne	86	64	67
Université PSL	77	71	73
University of Amsterdam	76	49	62
National University of Singapore	90	76	91

Table 3. Ranking from QS and The Time.

	Scores		
	QS University Ranking for Computer Science 2021	The Times University - Teaching Score 2021	The Times University ranking - Research Score 2021
Technical University of Munich	7	56	41
EPFL	71	56	17
Université PSL	7	81	38
University of Amsterdam	0	0	0
National University of Singapore	100	100	100

Table 4. Scores based on the ranking from QS and The Time.

Attribute: Cost (Pounds)

Source(s): Objective attribute from university websites

<https://www.studentenwerk-muenchen.de/en/international/international-students-in-munich/in-preparation/cost-of-living/>

<https://www.tum.de/en/studies/fees-and-financial-aid>

<https://www.epfl.ch/education/studies/en/rules-and-procedures/study-taxes/tuition-fee-other-fees/>

<https://www.epfl.ch/education/studies/en/financing-study/cost-of-living/>

<https://dauphine.psl.eu/en/training/school/tuition-fees>

[https://psl.eu/en/education/admissions/graduate-admissions/faq-graduate-admissions#:~:text=Tuition%20fees%3A%20~243%20euros%20%2F\(CVEC\)%20of%2092%20euros.](https://psl.eu/en/education/admissions/graduate-admissions/faq-graduate-admissions#:~:text=Tuition%20fees%3A%20~243%20euros%20%2F(CVEC)%20of%2092%20euros.)

<https://student.uva.nl/en/content/az/living-expenses/living-expenses.html?cb>

<https://student.uva.nl/en/content/az/tuition-fees/tuition-fees.html?cb>

<https://www.nus.edu.sg/oam/financial-aid/moe-tuition-grant-tuition-fees-and-cost-of-living/cost-of-living>

<https://www.comp.nus.edu.sg/programmes/pg/mcs/scholarships/>

	Cost			
	Tuition fee	Accommodation fee	Living cost	Total
Technical University of Munich	491	12146	7374	20010

	Cost			
	Tuition fee	Accommodation fee	Living cost	Total
EPFL - Swiss Federal Institute of Technology Lausanne	1952	7508	11882	21341
Université PSL	5531	4004	12012	21547
University of Amsterdam	12605	5005	5305	22915
National University of Singapore	27168	3586	4890	35644

Table 5. Cost, including tuition fee, accommodation fee and living cost.

	Scores		
	Tuition fee	Accommodation fee	Living cost
COMP			
Technical University of Munich	100	0	35
EPFL	95	54	98
Université PSL	81	95	100
University of Amsterdam	55	83	6
National University of Singapore	0	100	0

Table 6. Score based on tuition fee, accommodation fee and living cost.

Attribute: Location

Source(s): Objective attribute from university websites for location and university ranking agency website for city ranking

<https://www.tum.de/en/studies/degree-programs/detail/computational-science-and-engineering-cs-e-master-of-science-msc>

<https://www.epfl.ch/education/master/programs/computer-science/>

<https://psl.eu/en/education/masters-degree-computer-science>

<https://www.uva.nl/en/programmes/masters/computer-science/computer-science.html>

<https://www.comp.nus.edu.sg/programmes/pg/mcs/>

<https://www.topuniversities.com/city-rankings/2022>

	Location	QS Ranking -Best Student Cities 2022
Technical University of Munich	<i>Munich, Germany</i>	2
EPFL - Swiss Federal Institute of Technology Lausanne	<i>Lausanne, Switzerland</i>	19
Université PSL	<i>Paris, France</i>	9
University of Amsterdam	<i>Amsterdam, Netherland</i>	21
National University of Singapore	Singapore	17

Table 7. Locations and city ranking of the locations.

COMP	Score
Technical University of Munich	100
EPFL	11
Université PSL	63
University of Amsterdam	0
National University of Singapore	21

Table 8. Scores for the city ranking.

Attribute: Course Duration (Months)

Source(s): Objective attribute from university websites for MSc Computer Science

<https://www.tum.de/en/studies/degree-programs/detail/computational-science-and-engineering-cs-e-master-of-science-msc>

<https://www.epfl.ch/education/master/programs/computer-science/>

<https://psl.eu/en/education/masters-degree-computer-science>

<https://www.uva.nl/en/programmes/masters/computer-science/computer-science.html>

<https://www.comp.nus.edu.sg/programmes/pg/mcs/>

	Course Duration (Months)
Technical University of Munich	12
EPFL - Swiss Federal Institute of Technology Lausanne	12
Université PSL	12
University of Amsterdam	12
National University of Singapore	18

Table 9. Course duration.

COMP	Scores
Technical University of Munich	100
EPFL	100
Université PSL	100
University of Amsterdam	100
National University of Singapore	0

Table 10. Scores for Course Duration.

Overall Score

Source: V.I.S.A.

University	Total Scores	Ranking	Costs	Location	Course Duration
Université PSL	70	39	90	63	100
Technical University of Munich	64	32	52	100	100
EPFL - Swiss Federal Institute of Technology Lausanne	62	50	82	11	100
National University of Singapore	46	100	33	21	0
University of Amsterdam	35	0	52	0	100

Table 11. Scores of the alternatives

Appendix C: Initial alternatives and exclusion criteria

Table for initial screening using exclusion criteria.

Source(s):

<https://dauphine.psl.eu/en/training/school/tuition-fees>

<https://ethz.ch/en/studies/financial/tuition-fees.html>
<https://ethz.ch/en/the-eth-zurich/working-teaching-and-research/welcome-center/services-and-downloads/cost-of-living.html>
<https://inf.ethz.ch/studies/master/master-cs-2020.html>
[https://psl.eu/en/education/admissions/graduate-admissions/faq-graduate-admissions#:~:text=Tuition%20fees%3A%20~243%20euros%20%2F\(CVEC\)%20of%2092%20euros.](https://psl.eu/en/education/admissions/graduate-admissions/faq-graduate-admissions#:~:text=Tuition%20fees%3A%20~243%20euros%20%2F(CVEC)%20of%2092%20euros.)
<https://psl.eu/en/education/masters-degree-computer-science>
<https://student.uva.nl/en/content/az/living-expenses/living-expenses.html?cb>
<https://student.uva.nl/en/content/az/tuition-fees/tuition-fees.html?cb>
<https://www.comp.nus.edu.sg/programmes/pg/mcs/>
<https://www.comp.nus.edu.sg/programmes/pg/mcs/scholarships/>
<https://www.ed.ac.uk/students/new-students/ready-university/top-6-tasks/fees-finances/student-living-costs>
<https://www.ed.ac.uk/studying/international/finances>
<https://www.ed.ac.uk/studying/postgraduate/degrees/index.php?r=site/view&id=110>
<https://www.epfl.ch/education/master/programs/computer-science/>
<https://www.epfl.ch/education/studies/en/financing-study/cost-of-living/>
<https://www.epfl.ch/education/studies/en/rules-and-procedures/study-taxes/tuition-fee-other-fees/>
<https://www.imperial.ac.uk/study/pg/computing/computing/>
<https://www.imperial.ac.uk/study/ug/fees-and-funding/managing-your-money/living-costs/>
<https://www.nus.edu.sg/oam/financial-aid/moe-tuition-grant-tuition-fees-and-cost-of-living/cost-of-living>
<https://www.ox.ac.uk/admissions/graduate/courses/msc-advanced-computer-science>
<https://www.ox.ac.uk/admissions/graduate/fees-and-funding/living-costs>
<https://www.postgraduate.study.cam.ac.uk/courses/directory/cscsmpacs>
<https://www.postgraduate.study.cam.ac.uk/courses/directory/cscsmpacs/finance>
<https://www.postgraduate.study.cam.ac.uk/finance>
<https://www.studentenwerk-muenchen.de/en/international/international-students-in-munich/in-preparation/cost-of-living/>
<https://www.studentenwerk-muenchen.de/en/international/international-students-in-munich/in-preparation/cost-of-living/>
<https://www.tum.de/en/studies/degree-programs/detail/computational-science-and-engineering-cse-master-of-science-msc>
<https://www.tum.de/en/studies/fees-and-financial-aid>
<https://www.ucl.ac.uk/prospective-students/graduate/taught-degrees/computer-science-msc>
<https://www.ucl.ac.uk/prospective-students/graduate/your-life-london/living-costs>
<https://www.uva.nl/en/programmes/masters/computer-science/computer-science.html>

	Teaching in English?	Tuition fees and living cost					Difference from 35000 pounds	Course Duration	Has required material in the syllabus?
		Tuition fee	Accommodation fee	Living cost	Total in local currency	Total in pound			
National University of Singapore	Y	50000	6600	9000	65600	35615.51	615.51	1.5 year	Y
University of Oxford	Y	30330	8500	15187	54017	54017	19017	1 year	Y(MSc in Advanced Computer Science)
University of Cambridge	Y	37815	0	11788	49603	49603	14603	1 year	Y (MPhil ACS, no date)
EPFL - Swiss Federal Institute of Technology Lausanne	Y	2340	9000	14244	25584	21500.65	-13499.35	1 year	Y
ETH Zurich - Swiss Federal Institute of Technology	Y	2920	19080	34800	56800	47734.4	12734.4	2 years	Y
Nanyang Technological University, Singapore (NTU)	Y	N/A	N/A	N/A	N/A	N/A	4967.38	N/A	N
Imperial College London	Y	36500	10920	16209	63629	63629	28629	1 year	Y
UCL	Y	32100	11076	4108	47284	47284	12284	1 year	Y
The University of Edinburgh	Y	35900	7000	3000	45900	45900	10900	1 year	Y

	Teaching in English?	Tuition fees and living cost					Difference from 35000 pounds	Course Duration	Has required material in the syllabus?
		Tuition fee	Accommo- dation fee	Living cost	Total in local curr- ency	Total in pound			
Technical University of Munich	Y	588	14560	8840	2398 8	20159 .38	-14840.62	1 year	Y
Université PSL	Y	6630	4800	14400	2583 0	21707 .39	-13292.61	1 year	Y
University of Amsterdam	Y	15110	6000	6360	2747 0	23088 .34	-11911.66	1 year	Y

Table 12. Table of initial alternatives and their attribute values